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SYSTEM AND METHOD FOR THERAPY AND DIAGNOSIS COMPRISING OPTICAL COMPONENTS FOR DISTRIBUTION OF RADIATION

Field of the Invention

The invention relates generally to a system and a method for therapy and diagnosis in a mammal. More particularly, the system and method relate to a system and method for tumour therapy and diagnosis in a mammal. Even more particularly, the invention relates to a system and method for photodynamic therapy (PDT) and/or photothermal therapy (PTT) and/or diagnosis (PDD) of a site on and/or in a body, wherein radiation is conducted to the site for reaction with the radiation, wherein the system comprises a an optical mode selector for distribution of radiation from at least one source of radiation to a reaction site, and/or from the reaction site to at least one radiation sensor, respectively, and wherein the reaction site preferably is a tumour site with a tumour, such as a malignant tumour.

Background of the Invention

Within the field of medical therapy of tumour diseases, a plurality of treatment modalities has been developed for the treatment of malignant tumour diseases: operation, cytostatic treatment, treatment with ionising radiation (gamma or particle radiation), isotope therapy and brachytherapy employing radioactive needles are examples of common treatment modalities. In spite of great progress within therapy, the tumour diseases continue to account for much human suffering, and are responsible for a high percentage of deaths in Western countries. A relatively new treatment modality, photodynamic therapy, commonly abbreviated PDT, provides an interesting

complement or alternative in the treatment field. A tumour-seeking agent, normally referred to as a precursor or sensitizer, is administered to the body intravenously, orally or topically. It accumulates in malignant tumours to a higher extent than in the surrounding healthy tissue. The tumour area is then irradiated with non-thermal red light, normally from a laser, leading to excitation of the sensitizer to a more energetic state. Through energy transfer from the activated sensitizer to the oxygen molecules of the tissue, the oxygen is transferred from its normal triplet state to the excited singlet state. Singlet oxygen is known to be particularly toxic to tissue; cells are eradicated and the tissue goes in necrosis. Because of the localisation of the sensitizer to tumour cells a unique selectivity is obtained, where surrounding healthy tissue is spared. The clinical experiences, using in particular haematoporphyrin derivative (HPD) and aminolevulinic acid (ALA) have shown good results.

Sensitizers also exhibit a further useful property; to yield a characteristic red fluorescence signal when the substance is excited with violet or ultraviolet radiation. This signal clearly appears in contrast to the autofluorescence of the tissue and can be used to localise tumours and for quantifying the size of the uptake of the sensitizer in the tissue.

The limited penetration in the tissue of the activating red radiation is a big drawback of PDT. The result is that only tumours less than about 5 mm thickness can be treated by surface irradiation. In order to treat thicker and/or deep-lying tumours, interstitial PDT (IPDT) can be utilised. Here, light-conducting optical fibres are

brought into the tumour using, e.g. a syringe needle, in the lumen of which a fibre has been placed.

In order to achieve an efficient treatment, several fibres have been used to ascertain that all tumour cells are subjected to a sufficient dose of light so that the toxic singlet state is obtained. It has been shown to be achievable to perform dose calculations of the absorptive and scattering properties of the tissue. E.g., in the Swedish patent SE 503 408 an IPDT system is described, where six fibres are used for treatment as well as for measurement of the light flux which reaches a given fibre in the penetration through the tissue from the other fibres. In this way an improved calculation of the correct light dose can be achieved for all parts of the tumour.

According to the disclosure of SE 503 408, the light from a single laser is divided into six different parts using a beamsplitter system comprising a large number of mechanical and optical components. The light is then focused into each of the six individual treatment fibres. One fibre is used as a transmitter while the other fibres are used as receivers of radiation penetrating the tissue. For light measurement light detectors are mechanically swung into the beam path which thus is blocked, and the weak light, which originates from the fibres that collected the light which is administered to the tissue, is measured.

However, such open beam paths result in a strongly lossy beamsplitting and the resulting losses of light drastically impair the light distribution as well as the light measurement. Furthermore, such a system must often be adjusted optically, which is also an important drawback in connection with clinical treatments. The system is also

large and heavy and difficult to integrate into a user-friendly apparatus.

Thus, there is a need for a new compact device allowing distributing of radiation in a system for PDD, PDT and PTT for implementing a smart way of performing interactive interstitial treatment. One solution would be to use smart mechanical constructions for switching between different modes avoiding e.g. the lossy beamsplitters and allowing e.g. automatic calibration.

Such a mechanical solution to the above mentioned problems has been proposed in PCT/SE02/02050, wherein a distributor for radiation having two discs rotating relative each other is described. The radiation distributor couples optical fibres between different modes by rotational movement of fibres in these discs relative each other. For switching between several light sources to one fibre going to the patient, an assembly with a total of four discs is described.

However, although these mechanical constructions are improvements to the above described known IPDT system and although the above described problems are solved, these mechanical solutions have other limitations, related to e.g. mechanical inertia limiting the switching time between the different modes of a therapy and diagnosis system such as an interactive interstitial treatment system.

Thus, there is a need for a new compact device allowing distributing of radiation in a system for therapy and diagnosis in a mammal, wherein the therapy and diagnosis comprises PDD, PDT and PTT.

Summary of the Invention

The present invention overcomes the above identified deficiencies in the art and solves at least the above identified problems by providing a system and a method according to the appended patent claims, wherein a very practical and efficient implementation of interactive IPDT is achieved in that different optical measurements for diagnostics and dosimetry can be performed in an integrated and simple way by means of a system requiring minimal space. An important application of the invention is interactive, interstitial photodynamic therapy, and/or interactive photothermal tumour therapy.

According to one aspect of the invention, a system for therapy and/or diagnosis of a mammal comprises at least one first radiation source for emission of a diagnostic radiation and at least one second radiation source for emission of a therapeutic radiation, and at least one first radiation conductor adapted to conduct radiation to a site of the mammal. The system comprises an optical mode selector means for directing either said therapeutic radiation or said diagnostic radiation to said site through said at least one first radiation conductor.

According to an embodiment of the invention, a system and method for interactive interstitial photodynamic tumour therapy and/or photothermal tumour therapy and/or tumour diagnosis, comprises at least one radiation source, at least one radiation sensor and a radiation conductor which are brought to a tumour site, wherein the radiation conductor in use is employed as a transmitter and/or a receiver for conduction of radiation to and/or from the tumour site for diagnosis and/or therapy of a tumour at the tumour site, wherein a plurality of radiation conductors is

arranged for conducting radiation to and from the tumour site.

Optical elements have several advantages over mechanical arrangements. Among others, these advantages comprise: high switching speed between different system modes (diagnosis, photodynamic therapy, thermal therapy); compactness and stability of the system; excellent optical parameters; long life of the system due to no mechanical wear of the components and due to many more switching cycles during a life-cycle of the elements of the system.

Brief Description of the Drawings

In order to explain the invention more detailed, a number of embodiments of the invention will be described below with reference to the appended drawings, wherein

Fig. 1 is a schematic view illustrating an embodiment of the invention for interactive IPDT;

Fig. 2 is a schematic view illustrating another embodiment of the invention;

Fig. 3 is a schematic view over a further embodiment of the invention comprising optical splicers and an optical switch;

Fig. 4 is a schematic view illustrating the principle of an optical splicer used in an embodiment of the invention;

Fig. 5 is a schematic view illustrating another embodiment of the invention comprising optical switches;

Fig. 6 is a schematic view showing yet a further embodiment of the invention comprising modules with multiple diagnostic radiation sources; and

Fig. 7 is a schematic view showing yet a further embodiment of the invention comprising a 2xN optical switch.

Description of embodiments

Different embodiments of the system according to the invention are now described with reference to the drawings. In order to simplify the description of the embodiments, reference numerals for similar elements shown in the drawings are not repeated throughout all the figures.

A general description of a system 100 according to a first embodiment of the invention is given with reference to Fig. 1. Accordingly, a system 100 for interactive IPDT comprises at least one diagnostic radiation source 110. The diagnostic radiation source 110 generates a diagnostic radiation, whereby the diagnostic radiation preferably is diagnostic light. The radiation from at least one diagnostic radiation source 110 enters a diagnostic radiation coupling module 120. The radiation is preferably transmitted by means of radiation conductors 111. The diagnostic radiation coupling module 120 distributes the radiation further through one or more radiation conductors 122 to at least one corresponding mode selection module 140. Preferably the radiation conductors, described in this description of embodiments, are light guides such as optical fibres. The coupling of the diagnostic radiation to the radiation conductors 122 is accomplished by means of the diagnostic radiation coupling module 120, which e.g. comprises an optical switch or alternatively an optical splicer in series with an optical switch or alternatively with an optical splicer. This will be explained in more detail below.

The diagnostic radiation is further conducted to one of the mode selection modules 140, as shown in Fig. 1. The purpose of each mode selection module 140 is to guide diagnostic radiation from one of the diagnostic radiation sources 110 or therapeutic radiation from therapeutic radiation sources 130 through one of radiation conductors 142 to a treatment site 101 in a patient. All these radiation conductors 142 can release radiation to the reaction site 101 and receive radiation from said site. Thus, several measurements can be recorded and read out simultaneously. Each of the fibres 142 is proximally coupled to a separate mode selection module 140, e.g. fibre 141 is coupled to the mode selection module 140 illustrated as the first mode selection module of a plurality 125 of mode selection modules 140 / therapeutic light sources 130 in Fig. 1. The distal end of fibres 142 are appropriately positioned in different locations at the treatment site in order to enable an effective diagnosis or treatment of the patient. Moreover, the mode selection modules 140 couple radiation, which is transmitted from the distal end of fibres 142 towards the mode selection module 140, further towards at least one radiation detector 150. Alternatively a plurality of radiation detectors is used, either with different sensitivities or e.g. one detector for each mode selection module. The radiation coming from the treatment site 101 is transmitted to the radiation detectors 150 by means of radiation conductors 152, wherein a radiation conductor 151 is illustrated going from the topmost illustrated mode selection module 140 to radiation detector 150. The mode selection module 140 may comprise e.g. an optical switch or an optical splicer. A mode selection

module 140 is described in more detail below with reference to Fig. 4.

Fig. 2 illustrates another embodiment of an interactive interstitial treatment system, wherein the diagnostic radiation coupling module 120 is subdivided into two radiation distributor components 210 and 220. Radiation distributor 210 is as illustrated, a (Nx1) radiation distributor, i.e. a radiation distributor having N radiation inputs and one radiation output. In the illustrated example, the radiation distributor 210 is a 3x1 radiation distributor, which single output is coupled to a (1xn) radiation distributor 220, wherein n is the number of mode selection modules 125 as well as the number of radiation conductors 142 going to/from the treatment site 101. Radiation distributors 210, 220 may comprise, similar to mode selection module 140, e.g. an optical switch or an optical splicer. Exemplary radiation distributors 210, 220 are described in more detail below with reference to Figs. 3 and 5 illustrating different combinations of optical switches and/or splicers for radiation distributors 210, 220 and mode selection module 140 have different advantages concerning e.g. performance of the system.

In Fig. 3, a system is shown comprising an optical 3x1 splicer 310 and an optical 1x6 switch 320 as well as an optical splicer 330 as a mode selector in six modules 325. For interstitial treatment six therapeutic radiation sources 130, preferably laser light modules, are coupled to the six optical splicers 330. Each optical splicer 330 works in such a manner that the therapeutic radiation in therapy mode is coupled through the corresponding radiation conductor 142 to the treatment site 101. For switching to

the diagnostic mode, the therapeutic radiation source is switched off and subsequently one of the three diagnostic radiation sources 110 is activated. Thus, diagnostic radiation is conducted to splicer 310, where the radiation from the active diagnostic radiation source is coupled to the output of the splicer leading to the optical switch 320. The optical switch 320 couples the input radiation to an output radiation conductor 122 leading to the corresponding optical splicer 330 comprised in one of modules 325. From splicer 330, the diagnostic radiation is sent to the treatment site via a radiation conductor 142 connected to splicer 330, as shown in Fig. 3. Thus the diagnostic radiation is spread in the treatment site and partly to the remaining five radiation conductors 142 and partly reflected back. The diagnostic light from the patient is via splicer 330 sent to radiation detector 150. Thus five (=(n-1)) measurement values are obtained. Subsequently the optical switch 320 switches the incoming diagnostic radiation from the radiation source 110 to the next splicer 330 comprised in the next module 325. Thus five further measurement values are obtained. This measurement procedure is repeated until all six modules 325 have been activated, resulting in six times five (=30) measurement values. These thirty measurement values obtained may be used as input data for a tomographic modelling of the optical dose build up in the different parts of the tumour during the course of the treatment. This measurement procedure may be repeated with the remaining diagnostic light sources, yielding three times thirty (N*(n-1)) or ninety tomographic measurement values. Also the diagnostic light reflected at site 101 from the

illuminating radiation connector may be used for diagnostic purposes.

The splicer 310 may be a fibre splicer commercially available from, e.g., Polymicro Technologies.

As a basis for the optical switch 320 one may use a commercially available optical fibre switch from Piezosystem Jena Inc. The working principle of the splicer 330 is illustrated in Fig. 4. The splicer 330 may also be based upon a commercially available fibre splicer from Polymicro Technologies. The splicer has three input fibres 401-403, wherein radiation is transmitted along these fibres in the directions as indicated by arrows 421-423. The fibres 401-403 are fused together to a single fibre along a length as indicated by arrow 411. The whole splicer has a length as indicated by arrow 410. Thus radiation is transmitted via the fibres 401 and 402 to the single fused fibre at 400 and radiation from the single fused fibre at 400 is transmitted in the opposite direction to fibre 403. In the embodiment according to Fig. 3, fibre 401 is connected to the therapeutic radiation source, fibre 402 is connected to the diagnostic radiation source and fibre 403 is connected to the radiation detector. The splicer 330 can be made to transmit the main part of the diagnostic light emerging from the tissue site 101 via fibre 400 to fibre 403, assuring an efficient use of the occasionally faint diagnostic light. The splicer does not transmit light directly from fibres 401,402 to fibre 403.

Fig. 5 is a schematic diagram illustrating a further embodiment of the present invention, wherein an optical switch 510 switches between different diagnostic radiation sources 110. A further optical switch 530 works as a mode

selector, wherein either the therapeutic radiation source is coupled to the treatment site, the diagnostic radiation source is coupled to the treatment site, or the treatment site is coupled to the radiation detector. The optical switch 320 works similar as described above. This embodiment has the advantage that the time for switching from one diagnostic radiation source to another is not determined by the diagnostic radiation sources. Compared to an optical splicer, the optical switch 510 determines the time needed for switching between different radiation sources. This is in general much faster than turning off a light source at one input of a splicer and turning on another light source at another input of a splicer, wherein both light sources are coupled to the same output of the splicer. Furthermore an optical switch exhibits lower radiation losses than an optical splicer, which means that less powerful diagnostic radiation sources may be used than with optical splicer 310. However, an optical switch has to be actively controlled, whereas an optical splicer is a passive component. Moreover, the optical switch 530 prevents diagnostic light from directly entering the radiation detector 150 via a splicer, e.g. splicer 330. This unintended diagnostic radiation going to the detector may lead to "blooming" (saturation) of the detector 150. Instead of using a plurality of detectors 150 in order to avoid this phenomena, a single detector may be sufficient, which limits costs of the system according to the present embodiment.

Fig. 6 is a schematic diagram illustrating yet a further embodiment of the present invention. An optical splicer 630 is used similarly to the optical splicer 330. A

plurality of diagnostic radiation sources 610, each having a corresponding splicer 620 in a plurality of diagnostic radiation source modules 615, is comprised in this embodiment instead of an optical switch distributing the diagnostic radiation to a plurality of mode selection modules 140. Thus the cost for an optical switch, e.g. switch 320, is avoided. Furthermore the diagnostic radiation sources 610 may be modulated, so that the diagnostic radiation may be detected simultaneously by means of e.g. a lock-in technique or by multiplexing the signals, wherein the therapeutic radiation is preferably shut off in diagnostic mode.

Fig. 7 is a schematic diagram illustrating yet another embodiment of the present invention. The embodiment comprises an optical 2xn switch 710 coupling two diagnostic input radiation sources to n outputs of the switch 710. The switch 710 has two inputs, which may sequentially be directed to the different outputs. Such components are commercially available from e.g. Pyramid Optics. The mode selector/therapeutic radiation source module is a mode selector module 525 as described with reference to Fig. 5, but might also be replaced by a splicer module 625. In this way a more compact solution is achieved, as there is one component less in the system, e.g. splicer 310 or switch 510. An optical switch has also lower losses than a splicer, as already mentioned above.

The radiation conductors may be coupled to or connected to the different elements of the system according to the invention by any suitable method or means, including fibre optic connectors of different types, such as SMA, ST or FC connectors. Alternatively, the radiation conductors

may be fixed in holes by appropriate methods, e.g. glueing or mechanically fastening by, e.g., spring loaded elements.

For calibration purposes of the system according to the invention, the overall performance of the system is recorded prior to the treatment by direct measurements on a calibrated tissue phantom made of, e.g., a sterile intralipid-water solution or a sterile solid phantom made of, e.g., Delrin®. The performance of the therapeutic light sources may either be monitored by internal and/or external power meters.

The optical switches described may work according to different principles. One is the switching by direct fibre movement actuated by piezoelectric movement of the fibre in relation to output fibres. Another is the switching by microoptical beam deflection, which may be based on micromechanical components, such as microprisms or mirrors or by acousto-optical means, deflecting an optical beam to different output/input fibres.

In the following section, basic principles related to the system according to the invention will be described, wherein the description is based on a system with three diagnostic radiation sources 110 and six patient fibres 142.

By a reaction or treatment site we mean in the present context a site, where photodynamically active compounds will react in a tumour when subject to therapy e.g., by being forwarded through the lumen of injection needles which are placed in the tumour, these radiation conductors 142 are then fixed in the reaction site 101. Then the radiation conductors are moved forward to arrive outside the distal end of the needle. The same light conductor 142

is used continuously during the treatment for integrated diagnostics and dosimetry as well as to avoid that the patient be subjected to multiple pricks.

Preferably the diagnostic radiation sources 110 are lasers and/or light emitting diodes, out of which one is of the same wavelength as the lasers 130 utilised for the laser irradiation for photodynamic tumour therapy, but could be of lower output power. Suitable filters can be arranged to be inserted into the light path of the radiation sensor 150 in order to secure that the correct dynamic range is utilised for all measurement tasks and in order to prevent the above mentioned "blooming" of the radiation detector.

Certain of the diagnostic radiation sources 110 are utilised in order to study how radiation (light) of the corresponding wavelength is penetrating through the tissue of the tumour at the treatment site 101. When light from a radiation source is transmitted through the particular radiation conductor via the above described arrangements into the tissue, one of the radiation conductors 142, functions as a transmitter into the tumour, and the other five radiation conductors 142 in the tumour will act as receivers and collect the diffuse flux of light reaching them. The light collected is again conducted to the radiation sensor 150, as described above, and five different light intensities can be recorded on the detector array.

As an alternative to a specific wavelength, radiation from an optically broad light source such, as a white light source, and/or broadband light emitting diodes and/or line light sources can be coupled into the particular active

radiation conductor 142. On passage through the tissue to the receiving light conductor 142 in the patient, the well-defined spectral distribution of the radiation source will be modified by the tissue absorption. Then, oxygenated blood yields a different signature than non-oxygenated blood, allowing a tomographic determination of the oxygen distribution utilising the thirty different spectral distributions which are read out, five spectra at a time in the six possible different constellations. Such a determination of the oxygenation in the tumour is important, since the PDT process requires access to oxygen in the tissue.

Finally, a light source either for red, blue/violet or ultraviolet light, e.g. a laser, can be coupled to the particular active radiation conductor 142. Then fluorescence is induced in the tissue, and a sensitizer administered to the tissue displays a characteristic red fluorescence distribution in the red/near-infrared spectral region. The strength of the corresponding signal allows an approximate quantification of the level of the sensitizer in the tissue.

Since the short wavelength light has a very low penetration into the tissue, the induced fluorescence from such a source must be measured locally at the distal tip of the radiation conductor. For this task a filter may be inserted in front of detector 150 to reduce the reflected light at site 101 since this light will be many magnitudes larger than the diagnostic fluorescent light. A suitable self-contained fluorosensor is described in Rev. Sci. Instr. **71**, 510004 (2000).

By switching the diagnostic radiation source 110 sequentially through the different modules 125, the fluorescence that is proportional to the concentration of the sensitizer, is measured sequentially at the tips of the six radiation conductors. Since the sensitizer is bleached by the strong red treatment light, being particularly strong just around the tip of the radiation conductor 142 conducting radiation to the patient, it is essential to make this measurement before the start of the treatment.

If the tips of the radiation conductors 142 in addition are treated with a material, the fluorescence properties of which are temperature dependent, sharp fluorescence lines are obtained upon excitation, and the intensity of these lines and their relative strength depend on the temperature at the tip of the radiation conductor 142 being employed for treatment. Examples of such materials are salts of the transition metals or the rare earth metals. Thus also the temperature can be measured at the six positions of the six radiation conductors, one at a time or simultaneously. The measured temperatures can be utilised to find out if blood coagulation with an associated light attenuation has occurred at the tip of the radiation conductor 142 and for studies regarding the utilisation of possible synergy effects between PDT and thermal interaction. Since the lines obtained are sharp, they can be lifted off the more broad-banded fluorescence distribution from the tissue.

The sensitizer level can for certain substances be measured in an alternative way. Then the red light used for the light propagation studies is used to induce near-infrared fluorescence. This fluorescence penetrates through

the tissue to the tips of the receiving radiation conductors 142, and is displayed simultaneously as spectra obtained in the radiation sensor 150. A tomographic calculation of the sensitizer distribution can be performed based on in total thirty measurement values at each measurement occasion.

After diagnostic measurements and calculations have been performed, the fibres 142 optically coupled to the tissue of the patients can be utilised for therapy by switching off the diagnostic light sources and switching on the therapeutic radiation sources 130, as well as switching optical switches, if present in the system, accordingly so that therapeutic radiation sources are coupled to the patient fibres 142. The therapeutic radiation sources are preferably laser sources with a wavelength, which is adapted to the absorption band of the sensitizer. At the photodynamic tumour treatment a dye laser or a diode laser is preferably used, with a wavelength which is selected with regard to the sensitizer employed. For e.g. Photofrin® the wavelength is 630 nm, for δ-aminolevulinic acid (ALA) it is 635 nm and for phthalocyanines it is around 670 nm. The individual lasers are regulated during the treatment to a desirable individual output power. If desired, they may have built-in or external monitoring detectors.

The therapeutic treatment may be interrupted and new diagnostic data may be processed in an interactive method until an optimal treatment has been reached. This method may include synergy between PDT and hyperthermia, where an increased temperature is reached at increased fluxes of laser radiation. The whole process is controlled using a

computer, which does not only perform all the calculations but also is utilised for regulation and control of the system.

The present invention has been described above with reference to specific embodiments. However, other embodiments than the preferred above are equally possible within the scope of the appended claims, e.g. different optical coupler elements than those described above, performing the above method by hardware or software, etc.

Furthermore, the term "comprises/comprising" when used in this specification does not exclude other elements or steps, the terms "a" and "an" do not exclude a plurality and a single processor or other units may fulfil the functions of several of the units or circuits recited in the claims.

CLAIMS

1. A system for therapy and/or diagnosis of a mammal comprising at least one first radiation source for emission of a diagnostic radiation, at least one second radiation source for emission of a therapeutic radiation, and at least one first radiation conductor adapted to conduct radiation to a site of the mammal, **characterised** by an optical mode selector means for directing either said therapeutic radiation or said diagnostic radiation to said site through said at least one first radiation conductor.

2. The system according to claim 1, **characterised** in that said at least one first radiation conductor is adapted to conduct radiation from said site to at least one radiation detector.

3. The system according to claim 2, **characterised** by said at least one first radiation conductor having a distal end, wherein said distal end is brought to said treatment site, wherein at least one first radiation conductor is in use employed as a transmitter and/or a receiver for conduction of radiation from said at least one radiation source to and/or from the site for diagnosis and/or therapy.

4. The system according to claims 1 to 3, **characterised** in that said optical mode selector means is connected to said diagnostic radiation source, said therapeutic radiation source, said radiation conductor and said radiation detector, in such a manner that therapeutic

radiation or diagnostic radiation is transmitted to said site, or diagnostic radiation transmitted through the same and/or another radiation conductor of said first radiation conductors is received through said radiation conductor and transmitted to said radiation detector.

5. The system according to claims 1 to 4, **characterised** in that said optical mode selector means is an optical switch.

6. The system according to claims 1 to 4, **characterised** in that said optical mode selector means is an optical splicer.

7. The system according to claims 4 to 6, **characterised** by said diagnostic radiation sources being coupled to one of said mode selector means for transmission to said site, and the remaining mode selector means transmitting said diagnostic radiation to said at least one radiation detector, wherein said therapeutic radiation sources are inactivated.

8. The system according to claim 7, **characterised** in that one active diagnostic radiation source is coupled to one of said mode selector means by means of a device selected from the group comprising: an optical splicer and an optical switch, two optical switches, and a 2xN optical switch.

9. The system according to claims 4 to 6, **characterised** by each mode selector module having a similar

plurality of diagnostic radiation sources being coupled to each of said mode selector means for transmission to said site, only one diagnostic radiation source being active simultaneously for transmission of said diagnostic radiation to said site.

10. The system according to claim 9, **characterised** a similar plurality of diagnostic radiation sources being coupled to each of said mode selector by means of an optical splicer.

11. The system according to claims 4 to 6, **characterised** by one therapeutic radiation source being coupled to each of said mode selector for transmission of said therapeutic radiation to said site through each of said radiation conductors, wherein the diagnostic radiation sources are inactivated.

12. The system according to any of the preceding claims, **characterised** by said radiation sources being a light source for near-infrared (NIR), white, red, blue/violet or ultraviolet light.

13. The system according to claim 12, **characterised** by the radiation conductors second ends being treated by a material with temperature sensitive fluorescence emission.

14. The system according to any of the claims 1-11, **characterised** by said radiation sources being light

sources for coherent light of a single fixed wave-length and/or light emitting diodes.

15. The system according to any of the preceding claims, **characterised** by said radiation conductors being optical fibres.

16. The system according to claims 12-14, **characterised** by fluorescence being recorded through the same radiation conductor as the one transmitting radiation to the site.

17. The system according to claim 16, **characterised** in that for interactive photodynamic therapy one or several of the radiation conductors which are treated with the material with a temperature sensitive fluorescence emission are measuring the temperature at the site,

that the radiation which is sent to the site heats the treatment site,

that the intensity of the radiation is controlled by the measured temperature in order to regulate the temperature of the site at the individual radiation conductors.

18. The system according to any of the preceding claims, **characterised** in that said therapy and diagnosis are tumour therapy and tumour diagnosis and comprise interactive interstitial photo-dynamic tumour therapy, photothermal tumour therapy using hyperthermia, and tumour

diagnostics, whereby these modes are alternatively used during the same occasion of treatment of said tumour site.

19. A method for interactive interstitial photodynamic tumour therapy and/or photothermal tumour therapy and/or tumour diagnosis, wherein at least one radiation sensor and radiation conductor is connected to a tumour site and the radiation conductor is used as a transmitter and/or a receiver for conduction of radiation to and/or from a tumour site for diagnosis and therapy of a tumour at the tumour site,

characterised in that the switching between tumour therapy and tumour diagnostics is achieved in an automated way by switching between diagnostic radiation and therapeutic radiation by means of an optical mode selector means according to claim 1, and

that the results from the diagnostics control the therapy process by regulating a therapeutical radiation intensity depending on the results of the diagnostics until an optimal treatment of the tumour site has been achieved.

20. The method according to claim 19, **characterised** by alternatingly utilising interactive interstitial photodynamic tumour therapy, photothermal tumour therapy using hyperthermia, and tumour diagnostics during the same occasion of treatment of said tumour site.

21. Use of optical switches and/or optical splicers for a system for therapy and/or diagnosis of a mammal.

ABSTRACT

A system and method for therapy and diagnosis of a mammal comprising at least one first radiation source for emission of a diagnostic radiation, at least one second radiation source for emission of a therapeutic radiation, and at least one radiation conductor, preferably an optical fibre, adapted to conduct radiation to a site at or in said mammal, preferably a tumour site. An optical mode selector directs either or both the therapeutic radiation or the diagnostic radiation to the tumour site through the radiation conductors. In a therapeutic mode, all of the radiation conductors transmit therapeutic radiation to the tumour site. In diagnostic mode, one of the radiation conductors transmits diagnostic radiation to the tumour site and the remaining radiation conductors transmit the diagnostic radiation, which is spread through the tumour tissue to the remaining radiation conductors, to a radiation detector. Also diagnostic measurements could be performed using the same radiation conductor for both diagnostic radiation illumination and diagnostic radiation detection. The optical mode selector means is preferably an optical switch and/or an optical splicer. The system may be used for interactive interstitial photodynamic tumour therapy.

To be published with Fig. 1

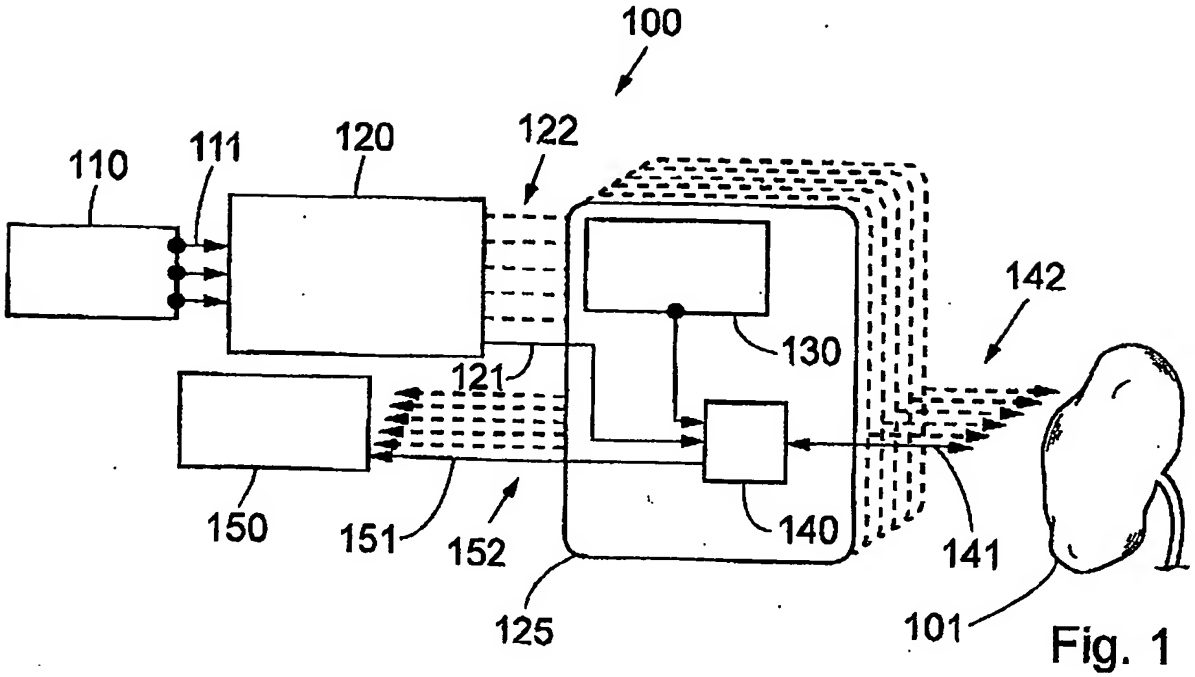
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Fig. 1

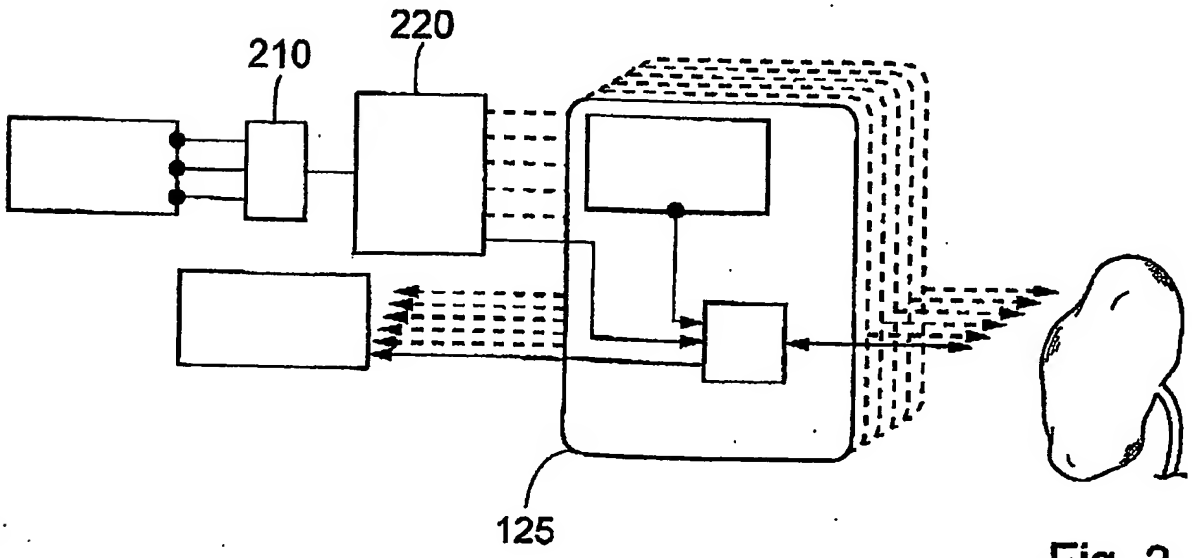
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Fig. 2

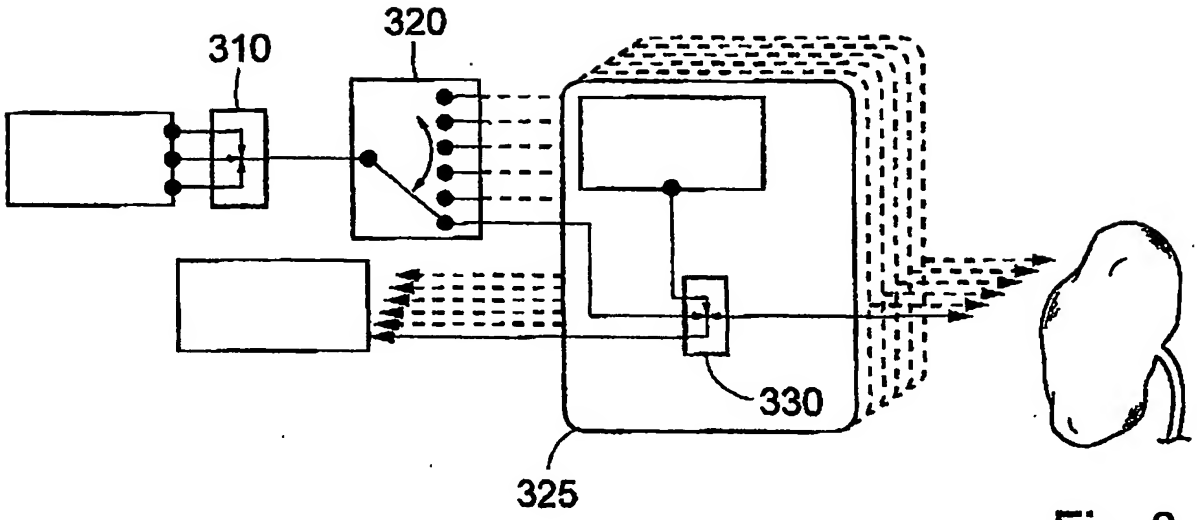

Fig. 3

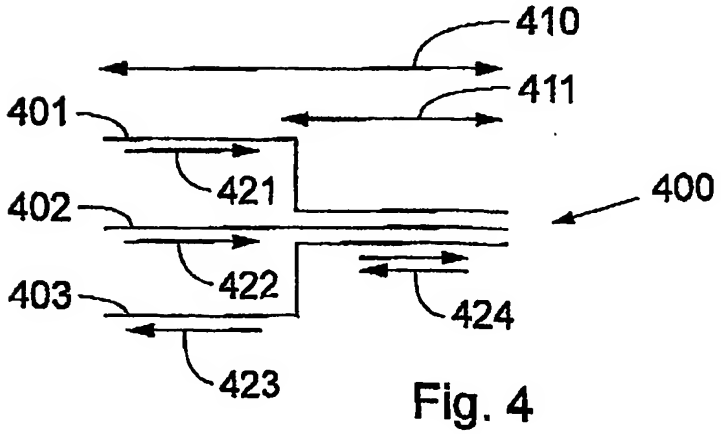

Fig. 4

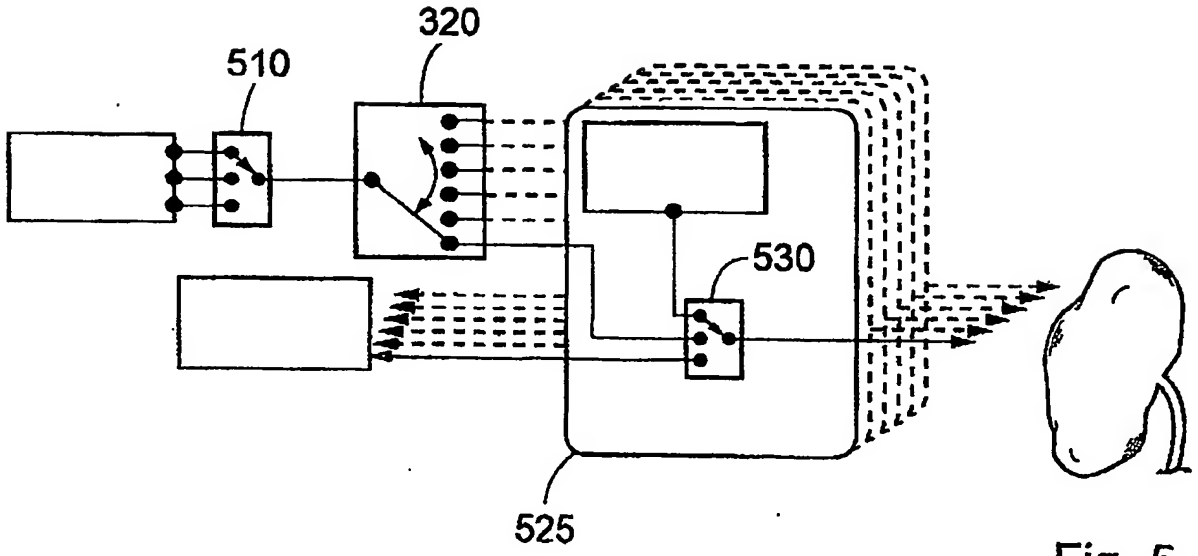

Fig. 5

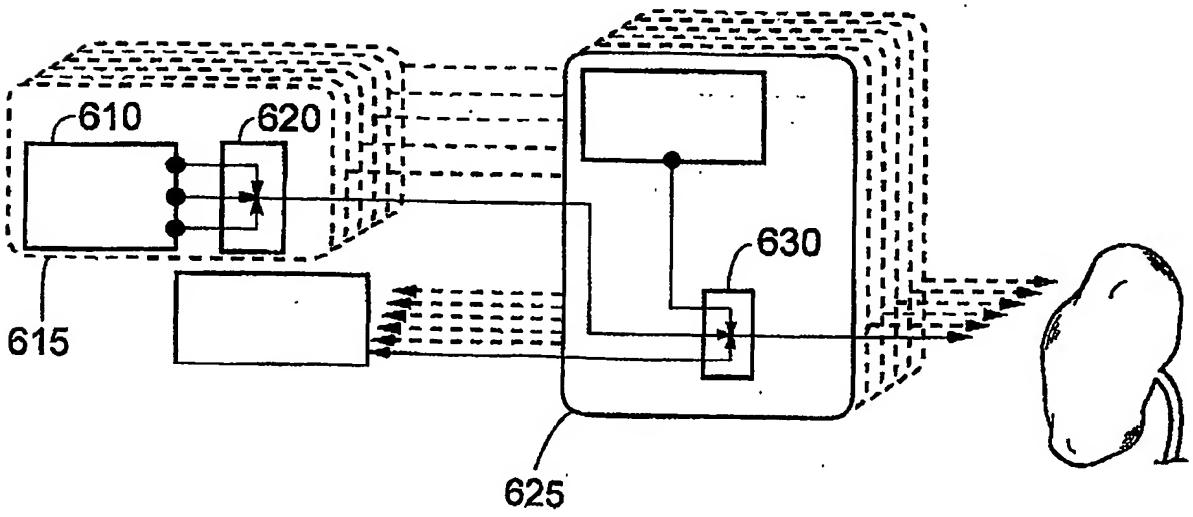

Fig. 6

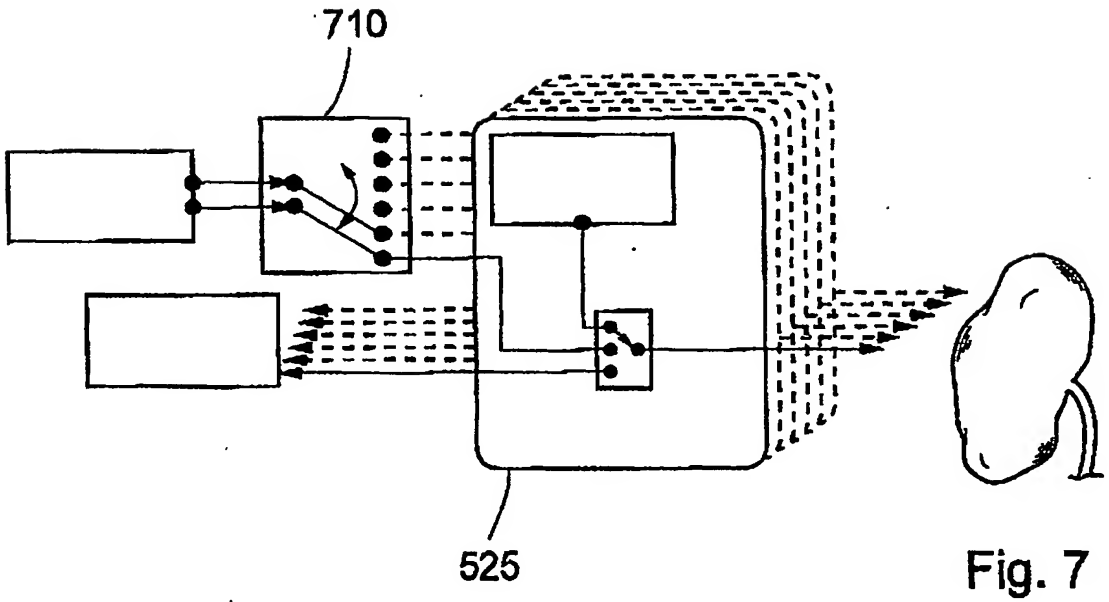

Fig. 7